Source Characteristics of California Earthquakes and
Attenuation Effects

14-08-001-G1872

Donald V. Helmberger
Seismological Laboratory
California Institute of Technology
Pasadena, CA 91125

(818)356-6998

Investigations

Our long term objective is to determine the characteristics of earthquakes occurring in Southern California. The basic strategy has been to study the larger modern events since they are well-recorded and then to compare the records from these events (Masters) to interpret historic events or recent ones to obtain quick preliminary results. The primary data sets for these studies are the PAS (low gain recording), long term running teleseismic stations such as De Bilt, starting in 1917, and some of the older Caltech stations. Essentially we think better locations can be obtained using a combination of waveform data and travel time constraints.

Results

In this summary period two studies will be emphasized; (a) on the rupture properties of the Loma Prieta earthquake which will be used to compare with the 1906 event, and (b) a re-examination of historic earthquakes along the San Jacinto fault zone.

We have used 24 broadband teleseismic and 48 components of local strong motion velocity records of the 1989 Loma Prieta earthquake in a formal inversion to determine the temporal and spatial distribution of slip. Separate inversions of the teleseismic data (periods 3-30 sec) or strong motion data (periods 3-30 sec) or strong motion data (periods 1-5 sec) result in similar models. The data require bilateral rupture with relatively little slip in the region directly updip from the hypocenter. Slip is concentrated in two patches; one centered 6 km northwest of the hypocenter at a depth of 12 km and with a maximum slip of 350 cm, and the other centered about 5 km southeast of the hypocenter at a depth of 16 km and with a maximum slip of 460 cm. The bilateral nature of the rupture results in large amplitude ground motions at sites located along the fault strike, both to the northwest and the southeast. This bilateral rupture also produces relatively modest ground motion amplitudes directly updip from the hypocenter, which is in agreement with the velocity ground motions observed at Corralitos. There is clear evidence of a foreshock (magnitude between 3.5 and 5.0) about 2 seconds before the main part of the rupture; the origin time implied by strong motion trigger times is systematically 2 seconds later than the time predicted from the high-gain regional network data. The seismic moment obtained from either of the separate data sets or both sets combined is about 3.0×10^{26} dyne-cm and the potency is 0.95 km^3, see Wald et al. (1991) for details.

The high level of seismic activity and the potential for large earthquakes in the San Jacinto fault zone, southern California make it desirable to have accurate locations and source parameters for as many previous events as possible. Prior to the installment of a dense seismic network in this region, earthquakes were located using only a few stations with generally poor azimuthal coverage resulting in considerable uncertainty in the locations. We relocate and obtain moment estimates for historic (pre- WWSSN) earthquakes in the western Imperial Valley by comparing the waveforms and travel times with recent earthquakes in the region. All the events are in the M_L 5.5-6.5 range.

The historic earthquakes occurred in 1937, 1942 and 1954. We use the 1968 Borrego Mountain, 1969 Coyote mountain, and 1987 Elmore Ranch earthquakes as calibration events. We employ regional and teleseismic data from continuously operating stations, with Pasadena, De Bilt, Berkeley, Ottawa and St. Louis recording most of the events. The waveforms imply that all the events are almost pure strike-slip events on vertical or near-vertical faults. Approximate values for the strikes were obtained and are within the range of observed strikes for well studied earthquakes in this region. The earthquakes are relocated by comparing S-P and surface wave -S travel times of historic events with the presumably well-located recent events. The relocations require only a small change in location for the 1954 event and a larger adjustment in the 1942 epicenter. It also appears that the 1969 earthquake may have been mislocated. The moment estimates are obtained by direct comparison of the maximum amplitudes. The moment estimates imply that the 1968 and not the 1942 earthquake is the largest to have occurred in the region this century. Previous magnitude estimates suggested the 1942 event was larger, see Bent and Helmberger (1991) for details.

References

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